

What is claimed is:

1        1. A method for processing a single channel audio signal to provide a plurality of  
2        audio-channel signals, comprising:

3                separating said single channel audio signal into a first separated signal  
4        characterized by a spectral pattern generally characteristic of speech, and a second  
5        separated signal;

6                processing said first separated signal to provide a first audio-channel signal; and  
7                modifying said second separated signal to produce the remainder of said plurality  
8        of audio-channel signals.

1        2. A method for processing an audio signal in accordance with claim 1, wherein  
2        said modifying includes:

3                dividing said second separated signal into a plurality of signals; and  
4                multiplying one of the latter signals by a predetermined factor.

1        3. A method for processing an audio signal in accordance with claim 2, wherein  
2        said factor is variable with respect to time.

1        4. A method for processing an audio signal in accordance with claim 2 wherein  
2        said factor applies a gain that is proportional to the time averaged magnitude of said first  
3        separated signal divided by the sum of the time averaged magnitude of said first separated  
4        signal and the time averaged magnitude of said second separated signal.

1        5. A method for processing an audio signal in accordance with claim 1, wherein  
2        said modifying includes

3                dividing said second separated signal into a plurality of signals; and  
4                *at least one of* *and said plurality of signals*  
time-delaying said second separated signal.

1        6. A method for processing an audio signal in accordance with claim 1, wherein  
2        said modifying step provides a left channel signal and a right channel signal.  
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1       7. A method for processing an audio signal in accordance with claim 6, wherein  
2 said modifying step further provides a left surround channel signal and a right surround  
3 channel signal.

1       8. A method for processing a single channel audio signal in accordance with claim  
2 1, wherein said first audio channel signal is a center channel signal.

1       9. A method for processing a single channel audio signal in accordance with claim  
2 8, wherein said processing said first separated signal includes multiplying said first  
3 separated signal by a first predetermined factor.

1       10. A method for processing a single audio signal in accordance with claim 9,  
2 wherein said modifying step comprises the step of multiplying said second separated signal  
3 by a second predetermined factor.

1       11. A method for processing a single audio signal in accordance with claim 10,  
2 wherein said first predetermined factor and said second predetermined factor are  
3 determined such that an increase the signal strength of said first separated signal coincides  
4 with a decrease in the signal strength of said second separated signal.

1       12. A method of processing a single channel audio signal in accordance with claim  
2 9, wherein said first predetermined factor is variable with respect to time.

1       13. A method for processing a single channel audio signal in accordance with  
2 claim 9, wherein said predetermined factor is proportional to the time averaged magnitude  
3 of said first separated signal divided by the sum of the time averaged magnitude of the first  
4 separated signal and the time averaged magnitude of the second separated signal.

1       14. An audio signal processing apparatus for processing a single-channel audio  
2 signal to provide a plurality of audio channel signals, comprising

3            a separator, for separating said audio signal into a first separated signal  
4 characterized by a frequency spectrum characteristic of speech, and a second separated  
5 signal; and

6            a first circuit coupled to said separator responsive to said second separated signal

7 for providing a first subset of said plurality of audio channel signals, coupled to said  
8 speech separator.

1 15. An audio signal processing apparatus in accordance with claim 14, wherein  
2 said first circuit comprises multiple signal paths for said second separated signal,  
3 one of said multiple signal paths furnishing a time delay.

1 16. An audio signal processing apparatus in accordance with claim 14, wherein  
2 said first circuit comprises multiple signal paths,  
3 at least one of said multiple signal paths comprising a multiplier.

1 17. An audio signal processing apparatus in accordance with claim 16, wherein  
2 said first multiple signal paths are constructed and arranged to subtractively combine a  
3 signal to which said variable gain has been applied with a signal path to which said variable  
4 gain has not been applied.

1 18. An audio signal processing apparatus in accordance with claim 14, wherein  
2 said first subset of said plurality of audio channel signals comprises a left channel signal  
3 and a right channel signal.

1 19. An audio signal processing apparatus in accordance with claim 18, wherein  
2 said first subset of said plurality of audio channel signals comprises a left surround channel  
3 signal and a right surround channel signal.

1 20. An audio signal processing apparatus in accordance with claim 14, wherein  
2 said separator includes a bandpass filter having a pass band corresponding substantially to  
3 the band of spectra characteristic of speech.

1 21. An audio signal processing apparatus in accordance with claim 14, further  
2 comprising a second circuit coupled to said separator and responsive to said first  
3 separated signal for providing a second subset of said plurality of audio channel signals.

1 22. An audio signal processing apparatus in accordance with claim 21, wherein  
2 said second subset comprises a single audio channel signal.

1 23. An audio signal processing apparatus in accordance with claim 22, wherein  
2 said single audio channel signal is a center channel signal.

- 1        24. An audio signal processing system comprising;  
2              an input terminal for a single input channel signal;  
3              a center channel output terminal for a center channel output signal  $C$ ;  
4              a plurality of other output terminals, for a corresponding plurality of other output  
5              audio channel signals;  
6                  a separator for separating said single channel input signal into a speech audio  
7              signal and a nonspeech audio signal;  
8                  a first circuit coupling said speech audio signal to said center channel terminal, and  
9                  a second circuit, coupling said separator and said plurality of output terminals  
10             responsive to said nonspeech signal, providing a corresponding plurality of other audio  
11             channel signals.
- 1        25. An audio signal processing system in accordance with claim 24, wherein said  
2            second circuit comprises multiple signal paths,  
3                  one of said multiple signal paths furnishing a time delay.
- 1        26. An audio signal processing system in accordance with claim 24, wherein said  
2            circuit comprises multiple signal paths,  
3                  at least one of said multiple signal paths comprising a multiplier.
- 1        27. An audio signal processing system in accordance with claim 26, wherein said  
2            multiplier is coupled to an other output terminal that is a left channel output terminal
- 1        28. An audio signal processing system in accordance with claim 26, wherein said  
2            multiplier is coupled to an other output terminal that is a right channel output terminal.
- 1        29. An audio signal processing system in accordance with claim 24, wherein said  
2            separator comprises a bandpass filter having a pass band corresponding substantially to the  
3            spectrum of speech signals.
- 1        30. An audio signal processing system in accordance with claim 24, further  
2            comprising a multiplier coupling said separator to said center channel output terminal and  
3            multiplying the output of said separator by a predetermined factor.

1           31. An audio signal processing system in accordance with claim 30, wherein said  
2 predetermined factor is variable with respect to time.

1           32. An audio signal processing system in accordance with claim 30 wherein said  
2 predetermined factor is proportional to the time averaged magnitude of said speech audio  
3 signal.

1           33. An audio signal processing system in accordance with claim 32 wherein said  
2 predetermined factor is proportional to the time averaged magnitude of said speech audio  
3 signal divided by the sum of the time averaged magnitude of the speech audio signal and  
4 the time averaged magnitude of said nonspeech audio signal.

1           34. An audio signal processing system in accordance with claim 24, wherein said  
2 second circuit provides a left channel signal  $L$ , a right channel signal  $R$ , a left surround  
3 channel signal  $L_s$ , and a right surround channel signal  $R_s$ ,

4           further comprising a downmixing circuit coupled to said plurality of other output  
5 terminals and to said center channel output terminal, for downmixing said plurality of  
6 other output audio channel signals and said center channel signal to provide a plurality of  
7 decodable audio channel signals.

1           35. An audio signal processing apparatus in accordance with claim 34, wherein  
2 said plurality of decodable audio channel signals consists of two decodable audio channel  
3 signals.

1           36. An audio signal processing apparatus in accordance with claim 34, wherein  
2 said plurality of decodable audio channel signals consists of three decodable audio channel  
3 signals.

1           37. A method for processing a single channel audio signal to provide two  
2 decodable audio channel signals decodable into five audio channel signals, comprising:

3           separating said single channel audio signal into a first separated signal  
4 characterized by a spectral pattern generally characteristic of speech, and a second  
5 separated signal;

6           processing said first separated signal to provide a center channel signal  $C$ ;

7 processing said second separated signal to provide a left channel signal  $L$ , a right  
8 channel signal  $R$ , a left surround channel signal  $L_S$ , and a right surround channel signal  $R_S$ ;

9 combining said center channel signal, the sum signal of said left surround and said  
10 right surround channel signals, and said left channel signal to produce a first of said two  
11 decodable audio channel signals; and

12 combining said center channel signal, said sum of said left surround and said right  
13 surround channel signals, and said right channel signal to produce a second of said two  
14 decodable audio channel signals.

1 38. A method for processing a single channel audio signal in accordance with claim  
2 37, further comprising scaling said center channel signal and said sum of said left surround  
3 and said right surround channel signals by center and surround factors respectively

1 39. A method for processing a single channel audio signal in accordance with claim  
2 38, further comprising reversing the phase of said sum component comprising one of said  
3 first and second decodable audio signal relative to said sum component comprising the  
4 other decodable audio signal.

1 40. A method for processing a single channel audio signal to provide three  
2 decodable audio channel signals subsequently decodable into five audio channel signals,  
3 comprising:

4 separating said single channel audio signal into a first separated signal  
5 characterized by a spectral pattern generally characteristic of speech, and a second  
6 separated signal;

7 processing said first separated signal to form a center channel signal comprising a  
8 first decodable audio signal;

9 processing said second separated signal to provide a left channel signal, a right  
10 channel signal, a left surround channel signal, and a right surround channel signal;

11 combining a sum of said left surround and said right surround channel signals with  
12 said left channel signal to produce a first of said two decodable audio channel signals; and

13 combining said sum of said left surround with said right surround channel signals,  
14 and said right channel signal to produce a third of said decodable audio channel signals.

1           41. A method for processing a single channel audio signal in accordance with claim  
2       40, further comprising scaling by a predetermined surround factor.

1           42. A method for processing a single channel audio signal in accordance with claim  
2       41 further comprising reversing the phase of one of said sum comprising one of said  
3       second and third decodable audio signals relative to the other of and said second and third  
4       decodable audio signals.

1           43. A method for processing two input audio channel signals to provide more than  
2       two output audio channel signals comprising:

3                 separating each of said two input audio channel signals into a first separated signal,  
4       characterized by a spectral pattern generally characteristic of speech, and a second  
5       separated signal;

6                 combining said first separated signal of said first input audio channel signal with  
7       said first separated signal of said second input audio channel signal to form a first of said  
8       more than two output audio channel signals;

9                 said second separated signal of said first input signal comprising a second of said  
10      more than two output audio channel signals; and

11                 said second separated signal of said second input signal comprising a third of said  
12      more than two output channel signals.

13           44. A method for processing two input audio channel signals in accordance with  
14       claim 43, wherein said second separated signal of said first input signal comprises a  
15       ~~provides a~~ left channel signal and said second separated signal of said second input signal  
16       comprises a right channel signal.  
  
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1           45. A method for processing two input audio channel signals in accordance with  
2       claim 43, wherein said first of said more than two output audio channel signals comprises  
3       a center channel signal.

1           46. A method for processing two input audio channel signal in accordance with  
2       claim 43, further comprising  
3                 differentially combining said second separated signal of said first input signal with  
4       said second separated signal of said second input signal to form a fourth of said more than

5 two output audio channel signals; and  
6 differentially combining said second separated signal of said second input signal  
7 with said second separated signal of said first input signal to form a fifth of said more than  
8 two output audio channel signals.

1 47 An audio signal processing apparatus for processing two audio channel signals  
2 to provide more than two output audio channel signals comprising,

3 a first separator, for separating a first of said two audio channel signals into a first  
4 separated signal characterized by a spectral pattern characteristic of speech and a second  
5 separated signal comprising a first of said more than two output audio channel signals;

6 a second separator, for separating a second of said two audio channel signals into a  
7 first separated signal characterized by a spectral pattern characteristic of speech, and a  
8 second separated signal comprising a second of said more than two output audio channel  
9 signals; and

10 a first combiner, for combining said first separated signal of said first audio channel  
11 signal and said first separated signal of said second audio channel signal to provide a third  
12 of said more than two output audio channel signals.

1 48. An audio signal processing apparatus in accordance with claim 47, further  
2 comprising

3 a second combiner for differentially combining said first output audio channel  
4 signal with said second output channel signal to provide a fourth of said more than two  
5 output audio channels; and

6 a third combiner for differentially combining said second output audio channel  
7 signal with said first output audio channel to provide a fifth of said more than two output  
8 audio channels.